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Feature Article - Use of Arima Modelling to Reduce Revisions

INTRODUCTION

The Australian Bureau of Statistics (ABS) publishes seasonally adjusted and trend estimates which are calculated from original estimates using the ABS seasonal adjustment package, SEASABS (ABS, 2001a).

The original estimates comprise seasonal, trend and irregular components. The seasonal component represents the systematic and calendar related effects, the trend component represents the underlying direction in the series, and the irregular component is the remaining component of the series after the seasonal and trend components have been removed. Seasonally adjusted estimates are calculated by estimating and removing the systematic and calendar related effects from the original estimates. The trend is calculated by smoothing the seasonally adjusted estimates. In order to best calculate a seasonally adjusted or trend estimate for a particular period, data are required for both previous periods and future periods. When the periods of interest are toward the end of the series, the future data are unknown. Therefore, both seasonally adjusted and trend estimates are subject to revision at the current end of a series once additional observations become available or the original estimates are revised (ABS, 2001a).

A major objective is to achieve accurate seasonally adjusted and trend estimates with small revisions at the current end. This paper demonstrates that an improvement can be achieved over the current ABS method by the use of a time series modelling technique called Integrated Autoregressive Moving Average (ARIMA).

ARIMA modelling will be implemented for the Monthly Retail Trade series (cat no. 8501.0) from August 2004. This method will be progressively introduced to other ABS time series as appropriate.

This technical note outlines the advantages of using ARIMA models to reduce revisions in the seasonally adjusted and trend estimates.

CURRENT SEASONAL ADJUSTMENT APPROACH

The current ABS seasonal adjustment approach, SEASABS, uses moving averages which are a set of weights of a given length designed to extract specific information embedded in the data. The moving averages used by SEASABS can estimate the seasonal component (Findley et. al, 1998) and the trend component (Henderson, 1916). These moving averages are applied interactively to a time series to derive seasonally adjusted and trend estimates. The moving average weights are centered at the point of interest. Therefore the centered moving average cannot be used at the end of a time series. To temporarily incorporate data points that extend beyond the observed end points of the source series, naive assumptions based on previously observed data points are made.

These naive assumptions are built into the design of the asymmetric end weights used in the seasonal moving averages and the trend moving averages. When the true observations become available in the source series, the difference between the true observations and the implicitly assumed future data points will lead to revisions between the initially calculated and the subsequent seasonally adjusted and trend estimates.

ARIMA MODELLING APPROACH

ARIMA modelling is a technique that can be used to extend estimates beyond the end of a series. For a comprehensive discussion of ARIMA models see Box and Jenkins (1976). See the Appendix for a brief overview.

ARIMA modelling relies on the characteristics of the series being analysed to project future period data. An ARIMA model projects values as a combination of past time series values and projected values based on past time series values, taking account of how "noisy" the series is. In general an ARIMA model provides more accurate projections than the ones implied by the asymmetric end weights.

As a result, use of ARIMA modelling generally results in a reduction in revisions to seasonally adjusted and trend estimates when subsequent data become available.

The data points projected by the ARIMA model are temporary, intermediate values that are used to improve the estimation of the seasonal factors. The projected data do not affect the original estimates and are not retained beyond the seasonal adjustment process. They are not accurate enough for use in their own right, but they are enough of an improvement over naive projections implicit in the asymmetric weights to produce better, more stable seasonal factor estimates.

ARIMA modelling is essentially a refinement of the existing seasonal adjustment methods used in ABS.

EVALUATION AND USE OF ARIMA MODELLING

Internationally, ARIMA modelling is a commonly used approach and it is recognised as a mature and good practice in seasonal adjustment. It has been incorporated into the X12ARIMA seasonal adjustment package (Findley et. al, 1998) which is used in most, if not all, major national statistical organisations, including Statistics Canada, Office for National Statistics (UK), Bureau of Labour Statistics (US), Bureau of the Census (US), and European Statistics (EU).

The ABS has previously extensively evaluated the use of ARIMA modelling. ABS (2001b) shows the results of testing ARIMA modelling against 820 series from 11 different collections. It calculates an average reduction in the absolute percentage revision to the seasonally adjusted estimates of 7.7%. For Retail Trade estimates across all time series, the average reduction in the size of the absolute percentage revision to the seasonally adjusted estimates was 6.7%.

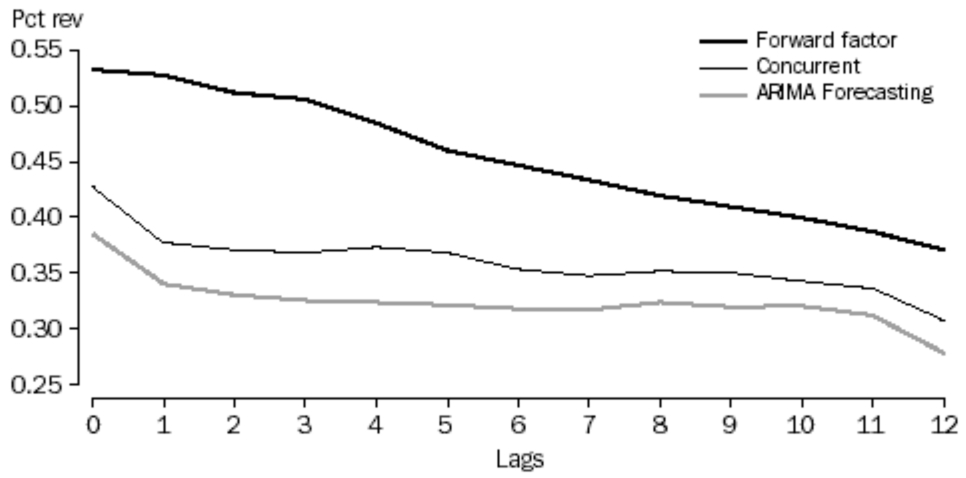
While ARIMA modelling on average reduces the revisions for individual collection areas, there can be individual time series where the techniques increase the size of the revisions. As part of the annual reanalysis, the ABS will evaluate the appropriateness of ARIMA models for each series. For most series, though, the overall average improvement and the sound theoretical framework will outweigh the chance of increased revisions. In these cases, ARIMA modelling will be adopted. In the rare cases where ARIMA modelling leads to increased revisions the current methodology will be retained.

Graphs 1 to 4 illustrate the average reduction in absolute percentage revisions for specified lags for the seasonally adjusted and trend estimates for two Retail Trade series using three

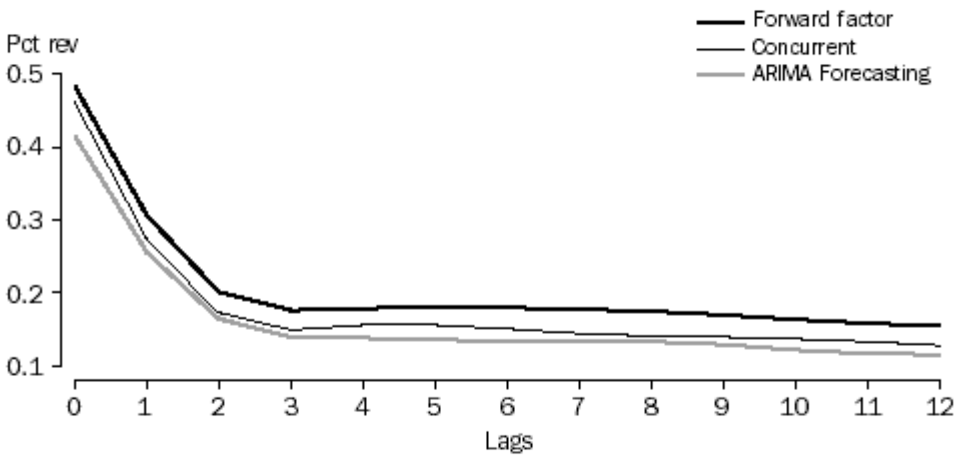
approaches to seasonal adjustment. The average of the absolute percentage revision against the lagged estimates is a global measure of the revision size of the estimates. It is calculated using all estimates at a specific lag. For example, the lag zero December 1991 estimate is the initial estimate using data up to December 1991. The absolute percentage revision is then calculated by taking this first initial estimate and comparing it to the final estimate which is calculated for December 1991 once there is at least an additional three years of information. The absolute value of the revision data for all the lag zero estimates are taken, and then averaged. The same method is used for all other lags. The absolute percentage revision from the initial to the final estimate is generally reduced as additional information becomes available.

Three approaches to seasonal adjustment are considered for comparison purposes. The first approach is forward factor seasonal adjustment where the seasonal component is estimated for twelve months ahead. Approach one is still used for some series within the ABS. The second approach is concurrent seasonal adjustment using asymmetric weights which uses information up to the current time point to estimate the seasonal factors. Approach two is the commonly used approach for ABS time series and is the approach currently used for retail series. The third approach is concurrent seasonal adjustment with ARIMA modelling and this will be used for Retail series from the August 2004 reference month onwards.

1 AVERAGE REVISION AT SPECIFIED LAGS FOR THE SEASONALLY ADJUSTED, ESTIMATES FOR AUSTRALIAN TOTAL RETAIL

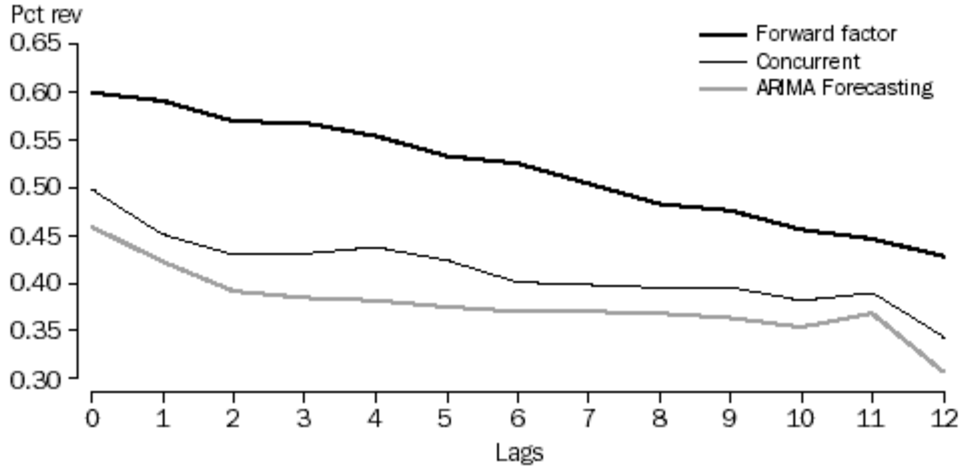


2 AVERAGE REVISION AT SPECIFIED LAGS FOR THE TREND ESTIMATES, FOR AUSTRALIAN TOTAL RETAIL

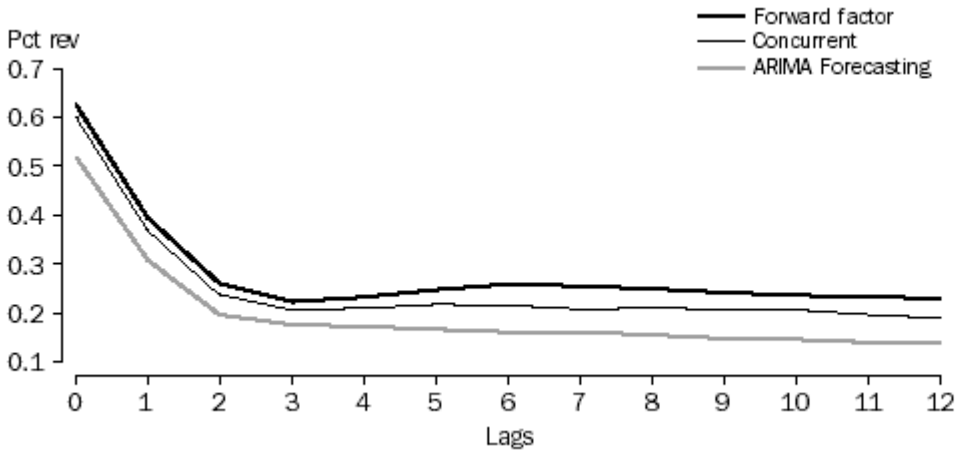


3 AVERAGE REVISION AT SPECIFIED LAGS FOR THE SEASONALLY ADJUSTED,

ESTIMATES FOR SUPERMARKET AND GROCERY STORES, QUEENSLAND



4 AVERAGE REVISION AT SPECIFIED LAGS FOR THE TREND ESTIMATES, FOR SUPERMARKET AND GROCERY STORES, QUEENSLAND



Graphs 1 to 4 illustrate that, on average, the use of ARIMA modelling with concurrent seasonal adjustment reduces the average absolute percent revisions for seasonally adjusted and trend estimates when compared to both forward factor and concurrent seasonal adjustment. The improvement is greater for the seasonally adjusted estimates than for the trend. In part this is because the trend converges to its final value much more quickly (within a lag of only three to four months) than the seasonally adjusted series (which can take several years to stabilise).

It should be noted that these graphs only give a broad indication of what is expected in practice, as the ARIMA modelling options used will be different for each individual series.

IMPLEMENTATION ISSUES

The ABS plans to move to ARIMA modelling for individual collections at the same time as their annual seasonal reanalysis is undertaken. Each annual reanalysis will confirm which ARIMA models are appropriate, or if some tailoring of the ARIMA modelling options is required for individual time series. In rare cases where ARIMA modelling is unsuitable, the existing methodology will be retained. Details of the timing of the move to ARIMA modelling will be announced in the respective publications. A switch to ARIMA modelling will cause minor revisions to previously published seasonally adjusted and trend estimates.

As part of the switch to ARIMA modelling, the treatment of the calendar related component (trading day) has changed. Trading day adjustment is a correction which allows for the different composition of days within each month. Previously this correction occurred internally as part of

the seasonal adjustment process. Trading day corrections will now be estimated and removed prior to the seasonal adjustment process. This will ensure that an appropriate ARIMA model can be chosen.

FURTHER INFORMATION

For further details on the introduction of ARIMA modelling in the Retail Trade Series, please contact Michael Gurney (02 6252 5487, <m.gurney@abs.gov.au>) or for more general queries about ARIMA, please contact Craig McLaren (02 6252 6540, <craig.mclaren@abs.gov.au>).

APPENDIX

The form for an ARIMA model for a time series, denoted by y_t, is given by

$$\phi(B)\Phi(B^s)(1-B)^d(1-B^{12})^D y_t = \theta(B)\Theta(B^s)a_t \qquad (1)$$

where s is either 4 for quarterly series or 12 for monthly series, B is the standard backshift operator, ie $By_t = y_{t-1}$, a_t is a normally distributed noise component and

$$\phi(B) = 1 - \phi_1 B - \ldots - \phi_p B^p$$
$$\Phi(B^s) = 1 - \Phi_1 B^s - \ldots - \Phi_P B^{sP}$$
$$\theta(B) = 1 - \theta_1 B - \ldots - \theta_q B^q$$
$$\Theta(B^s) = 1 - \Theta_1 B^s - \ldots - \Theta_Q B^{sQ}$$

The model order is defined by the choice of p, d, q, P, D and Q. The model parameters ϕ_i, Φ_i, θ_i and Θ_i are estimated from the data y_t. The model parameters will be different for each time series. The model order can be the same for different time series. The ARIMA model in (1) can be denoted in simplified notation by $(p\ d\ q)(P\ D\ Q)_s$. A standard ARIMA model is the airline model which is written as $(0\ 1\ 1)(0\ 1\ 1)_s$.

REFERENCES

Australian Bureau of Statistics (2001a). Introductory course on Time Series Analysis, (available as a free download from www.abs.gov.au)

Australian Bureau of Statistics (2001b). Methodology Advisory Committee paper ‘Use of ARIMA models for improving revisions of X-11 seasonal adjustment‘, November 2001, available from www.abs.gov.au.

Australian Bureau of Statistics (2004). Retail Trade, Catalogue number 8501.0, Canberra, Australia.

Box, G. E. P. and Jenkins G. M. (1976). Time Series Analysis: Forecasting and Control (revised edition), Holden Day, San Francisco.

Findley, D.F., Monsell, B.C., Bell, W.R., Otto, M.C. and Chen B. (1998). New Capabilities and Methods of the X-12-ARIMA Seasonal-Adjustment Program. Journal of Business and Economic Statistics, Vol. 16, No. 2., 127-177.

Henderson, R. (1916). Note on Graduation by Adjusted Average. Transactions of the American Society of Actuaries, 17, 43-48.

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